Fly Ash Utilisation for Value Added Products
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Sintering studies on fly ash and clay mixes

SANJAY KUMAR, U. S. DAS and K. K. SINGH
National Metallurgical Laboratory, Jamshedpur

ABSTRACT

Fly ash and clay were mixed in various ratios and compacted using uniaxial pressure in the range of 150 to 300 kg/cm² followed by heat treatment at 1000 to 1250°C with different soaking time. The physical properties of the sintered samples were evaluated in respect to fly ash content, compacting pressure, sintering temperature and soaking time. The influence of above parameters on the properties of sintered products has been discussed in the paper.

***Key words** : Sintering studies, Fly ash mixes, Clay mixes*

1.0 INTRODUCTION

Fly ash is a by-product of thermal power plants resulting from the combustion of pulverised coal in the coal fired furnaces. The particles of fly ash range in size from <5 to 120μm in spherical diameters. Being light in weight, it has potential to get air borne and pollute the atmosphere. The annual generation of fly ash in India is so enormous that in-spite of the development of a number of technologies for its utilisation, only a very small percentage (<10%) is utilised and rest is being dumped on the open ground causing serious environmental problems.

The major constituents of fly ash are SiO_2, Al_2O_3 and Fe_2O_3 along with some minor constituents such as CaO, MgO and TiO_2. The main active constituent of fly ash is amorphous silica in hollow, spherical glassy particles called cenosphere. The chemistry of fly ash enables its use as raw material for ceramic industry as a part replacement of traditional clay. The potential of fly ash as a raw material for ceramic applications was reviewed by Sen et al[1]. Several authors[2,3] have studied the effect of fly ash addition on the conventional tile properties and reported its suitability. Xing et al.[4] studied the sintering mechanism of ceramic tiles containing 60-70% fly ash and reported good strength when fired at 1000-1080°C. Some authors[5,6] also reported good strength when fly ash in the range of 50-60 % was used along with clay and other tile body raw materials. Kumar et.al.[7,8] observed that addition of 30-50% fly ash in conventional tile composition improves the strength and scratch hardness.

The present investigation was carried out to study the sintering characteristic of fly ash and clay mixtures to assess their potential for the development of various ceramic products such as tiles, bricks, sanitaryware, etc.

2.0 EXPERIMENTAL

Fly ash collected from one of the captive power plant of Orissa and locally available clay were used in the present investigation. Five compositions have been developed using fly ash/clay ratio as 4:1, 3:2, 1:1, 2:3 and 1:4. The raw materials were wet milled, dried, powdered and converted into the shape of small globules using water as binder. The ready powder was compacted into 50mm diameter disc using uniaxial pressure in the range of 150 to 300 kg/cm^2. The discs were then subjected to heat treatment in an electric furnace at 1,000 to 1,250°C with 30 to 120 minutes soaking time in oxidising atmosphere. The rate of heating was maintained at 10°C/minute for all the cases. The sintered products finally obtained, were characterised in terms of linear shrinkage, water absorption, bulk density and bending strength by standard procedures.

3.0 RESULTS AND DISCUSSION

3.1 Chemical Analysis : The chemical analysis of the fly ash and clay used in the present study is given in table-1.

Table - 1: Chemical Analysis of Raw Materials

Constituent	Fly ash (Weight %)	Clay (Weight %)
SiO_2	61.87	51.79
Al_2O_3	26.73	26.82
Fe_2O_3	4.77	2.14
CaO	1.73	3.90
MgO	0.33	—
TiO_2	1.05	0.55
L.O.I.	0.18	10.56

Although the fly ash was highly siliceous in nature as shown in table-1 which is considered favourable for ceramic application, the higher iron content (4.77 wt.%) restricts its application and allows it to use in limited quantity. The low loss on ignition of fly ash is another suitable property for its ceramic application. The high loss on ignition of clay may be due to the presence of carbonaceous matter and can be reduced by washing.

3.2 Physical Properties

3.2.1 *Colour :* The colour of fired samples has changed gradually from light brown to darker shades with the increasing heating temperature and fly ash content. Increasing amount of iron and other impurities with increasing fly ash is the reason for this change. The change in colour with temperature is because of transformation from ferric to ferrous state.

3.2.2 *Relation between fly ash content and properties :* The relation between physical properties of sintered specimens such as linear shrinkage, bulk density, water absorption and bending strength to fly ash content, when compacting pressure, heating temperature and soaking time were kept constant, is shown in figure 1. It was found that linear shrinkage(fig.1a) of the samples decreases with increasing fly ash content which may be due to presence of more amorphous silica and which acts as filler material. The bulk density was found maximum (2.12 gm/cc) when 40% fly ash was used (fig.1b). This may be due to the better sintering at optimum fly ash/clay ratio i.e. 2:3. This observation was further supported by the achievement of maximum bending strength at the same fly ash/clay ratio (fig.1d). The decrease in bending strength with respect to fly ash content is because of increasing iron content and other impurities which caused more liquid phase formation and consequently loss in strength.

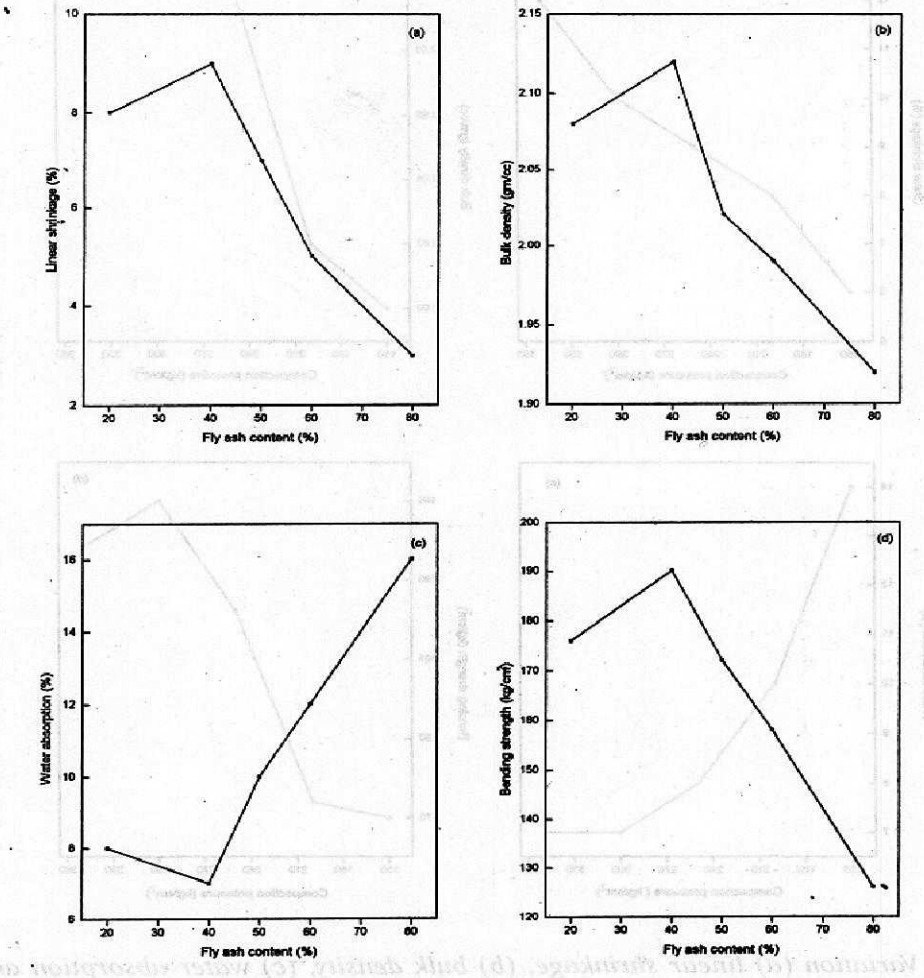

Fig. 1 : Variation (a) linear shrinkage, (b) bulk density, (c) absorption and (d) bending strength in relation to fly ash content fired at 1250°C (60 minutes soaking) and compacted at 300 kg/cm² pressure

3.2.3 *Relation between compacting pressure and properties :* Figure 2 includes the relation between physical properties and compacting pressure, when fly ash content, temperature and soaking time were kept constant. A linear relationship between firing shrinkage, bulk density and bending strength with compacting load was noted which increased with the increasing pressure up to 300 kg/cm^2, while the water of absorption values decrease. When the pressure was further increased from 300 kg/cm^2, foliation in green samples was reported. The improvement in properties with the increasing load is due to better compaction which helped in achieving more green density and consequently better sintering leading to improved properties.

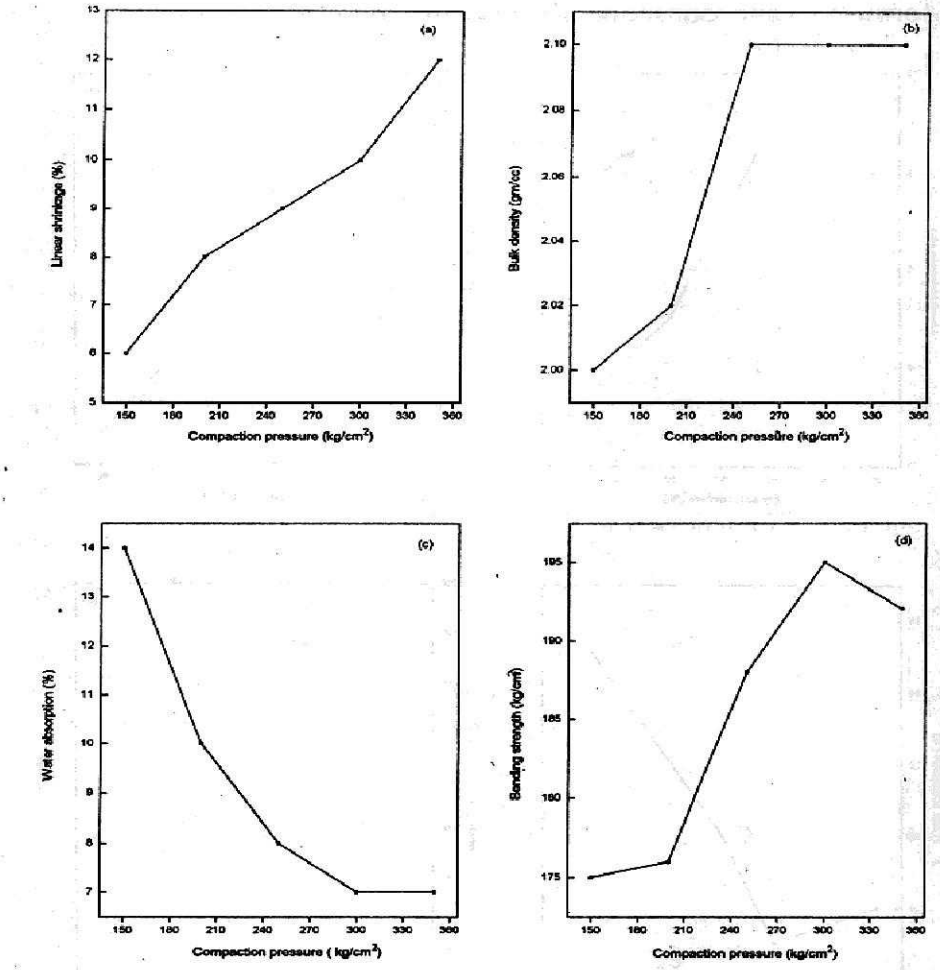

Fig. 2 : Variation (a) linear shrinkage, (b) bulk density, (c) water absorption and (d) bending strength in relation to compaction pressure of 40% fly ash based composition fired at 1250°C (60 minutes soaking)

3.2.4 *Relation between heating temperature and properties* : The variation in physical properties in relation to heating temperature is shown in figure 3, when fly ash content, compacting pressure and soaking time were kept constant. The linear shrinkage of the samples were increased with increasing temperature and reached to maximum at 1300°C (fig.3a). The bulk density and water of absorption have improved with the increasing temperature and achieved the maximum value at 1300°C (fig. 3b & c) while the maximum bending strength was attained at 1250°C (fig. 3d).

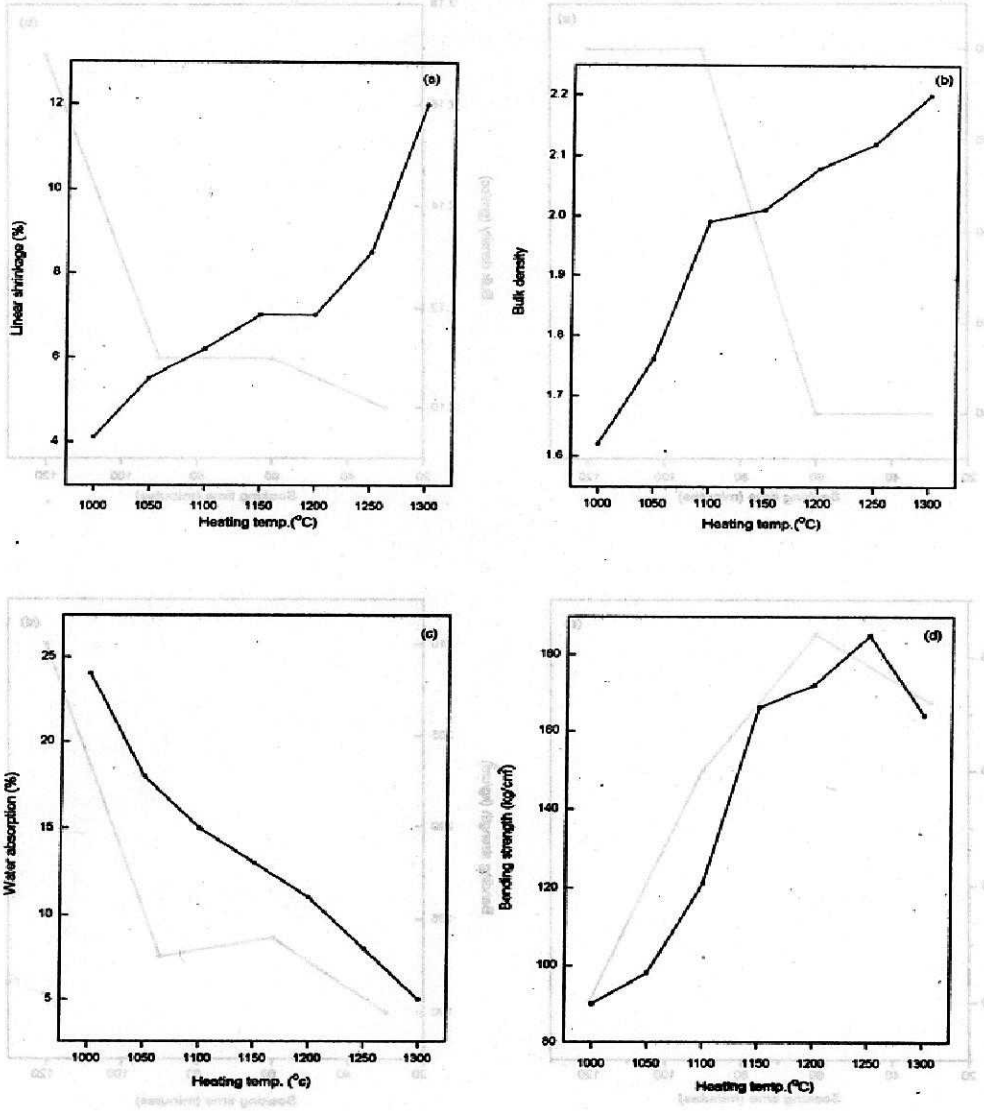

Fig. 3 : Variation in (a) linear shrinkage, (b) bulk density, (c) water absorption and (d) bending strength in relation to heating temp. (60 minutes soaking) of 40% fly ash based composition compacted at 300 kg/cm² pressure

3.2. *Relation between soaking time and properties :* The effect of soaking time on the physical properties of samples is shown in figure 4, when fly ash content, compacting load and heating temperature were kept constant. Not much variation on linear shrinkage and bulk density was reported (fig. 4a & b). However, slight improvement in water absorption and bending strength was noted (fig.4c & d) with increasing soaking time.

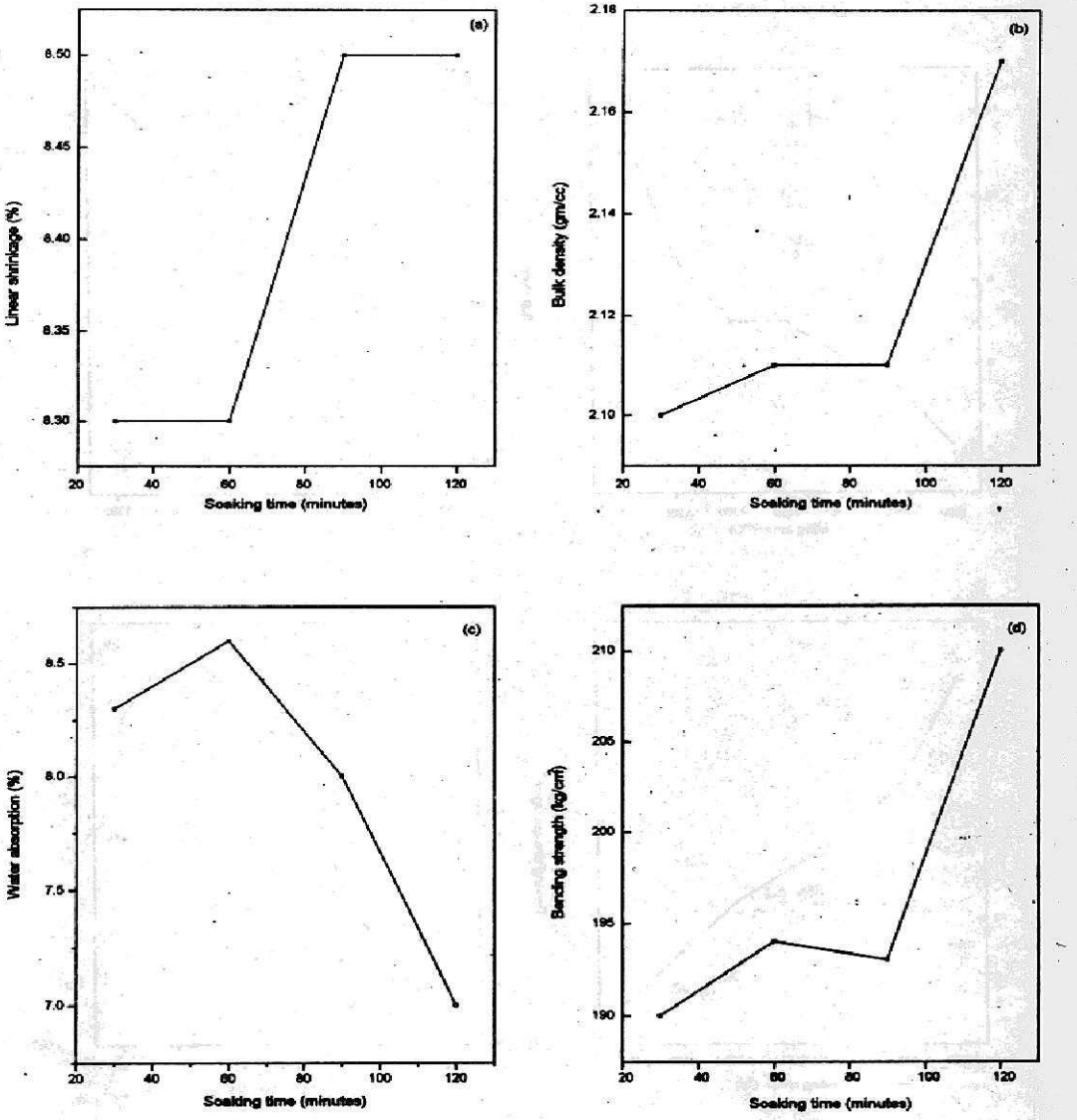

Fig. 4 : Variation in (a) linear shrinkage, (b) bulk density, (c) water absorption and (d) bending strength in relation to heatig temp. (60 minutes soaking) of 40% fly ash based composition compacted at 300 kg/cm² pressure

4.0 CONCLUSIONS

On the basis of the sintering study, the following conclusions can be drawn :

1. The fly ash/clay in the ratio of 2:3 was found optimum and gives the best result in terms of properties. Further increase in fly ash content leads to deterioration in the properties.
2. The properties of the sintered products have improved with increasing compacting pressure and attained the maximum value at 300 kg/cm^2. No further improvement in properties was reported above this pressure.
3. A significant improvement in strength was obtained with increasing temperature which attained its maximum at 1250°C. But above this temperature, strength loss was observed due to formation of more liquid phases.
4. With the increase of soaking time, an improvement in all the properties especially water absorption and bending strength was observed.

5.0 ACKNOWLEDGEMENT

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